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SPRAY DISTRIBUTION WITH BOOM SPRAYERS

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Obtaining uniform distribution of insecticide sprays is a very important factor in the control of forage-crop insects in the Nation's stepped-up program on grassland agriculture. It is important to apply the spray uniformly so that there will be sufficient insecticide on all parts of the plants to kill the insects. It is equally important that not enough residue remains on the plants at time of harvest or pasturing to injure the livestock that consumes the sprayed forage.

Boom sprayers are used for applying insecticides to field crops and are especially useful for treating alfalfa and red clover. Considerable testing has been done to determine how uniformly a boom sprayer applies the insecticide to forage crops, and some of the results are reported with the hope of stimulating further research.

Factors Considered in the Development of Sprayer

A boom sprayer must have a means of applying pressure to the liquid. This can be done with any of the standard pumps, but usually with a gear or piston pump. Sometimes air or carbon dioxide is used. A pressure sufficient to atomize the liquid is necessary, generally between 20 and 100 pounds per square inch. The liquid flows under pressure to a boom and is released through nozzles spaced along the boom. On leaving the nozzles the liquid is atomized and projected downward onto and throughout the foliage.

The uniformity of the deposit depends on (1) the density and height of the foliage, (2) the forward speed of the sprayer, and (3) the uniformity of the spray pattern. The uniformity of the spray pattern from the boom depends on the output and spray pattern from each nozzle, as well as the spacing and the distance of the nozzles from the foliage.

1/ These investigations were conducted while Mr. Yeomans was with the Bureau of Entomology and Plant Quarantine. He is now with the Biological Sciences Branch of the Agricultural Marketing Service.

If the height and density of the foliage are uniform throughout the field, the output per acre and the boom height can be set accordingly. If the area varies in foliage density, it will be necessary to change the output per acre by changing the forward speed of the sprayer. The height of the boom should be changed if the foliage varies more than 2 inches in height over large areas.

A speedometer was adapted for determining the forward speed of the sprayer.

Description of Sprayer

A hand-pushed boom sprayer (fig. 1) was constructed so that small plots could be sprayed as uniformly as possible. This sprayer rolls on two bicycle wheels 100 inches apart. The framework consists of front and back pieces of 1-inch angle iron 36 inches apart connected by cross-pieces of similar angle iron on each side of each wheel, and crosspieces of 3/4-inch angle iron at the 1/3 and 2/3 distances. A U-shaped handle made of 3/4-inch angle iron extends back 33 inches and is 32 inches wide. This framework is supported on the wheels by flat pieces of iron 2 by 1/4 inches and 14 inches long, welded to the frame. The outside pieces are hinged and contain holes 2 inches apart so that the height of the frame can be easily changed.

The speedometer is mounted so that it can be easily seen by the operator. Each bicycle wheel is 26 inches in diameter, and one wheel has a 15 1/2-inch diameter V-belt drive attached to it. A pulley 1 1/2 inches in diameter is attached to a gear box which turns the cable attached to the speedometer. A V-belt 1/2 inch by 62 inches connects the pulley with the drive. The speedometer is geared to read 20 m.p.h. when the machine actually travels 2 m.p.h.

An air tank (a 2,100-cubic-inch oxygen cylinder) is mounted on the frame, and has a pressure gage and valves so that it can be filled with air at a pressure between 100 and 200 pounds per square inch. The air from this tank then flows through a pressure regulator which provides a constant pressure to the top of the tank holding the liquid. This tank is a 3 1/2-gallon compression sprayer with an outlet fitting welded to the bottom so that it can be completely drained. An air fitting at the top is connected by hose with the air tank. The liquid tank is then connected by a 1/2-inch hose to a strainer, a quick-shutoff valve, and then to the center of the boom.

The boom is 96 inches long, made of 1/2-inch pipe with fittings at each end and at every foot to hold eight nozzles. An additional fitting at the center connects it with the quick-shutoff valve. Supports for the boom allow it to be raised 20 inches above the frame or lowered 8 inches below. It extends 18 inches forward of the frame.

Kinds of Nozzles

With this machine various nozzles can be used, but the most suitable are those of the flat-spray type. The flat-spray nozzles are generally of two kinds. In one kind the orifice is drilled part way and then the outer half of the disk is milled with a slot to complete the orifice. These nozzles therefore do not have a round hole completely through the outer piece, and any attempt to clean out this outer piece with a round pin will ruin the orifice. Some of the nozzles of this kind that were tested had been damaged in this manner. All new nozzles of the Spraying Systems Company's model No. 650067[2/] gave the standard output with water at 20, 40, and 60 pounds' pressure.

In the second kind of nozzle there are two pieces, both of which are drilled completely through. The inner piece has the hole enlarged by countersinking of the outer part. The outer piece has grooves cut on the inner and outer surfaces and perpendicular to each other. The inside groove fans out from the orifice to a width about three times that of the orifice. When nozzles of this type were tested, a great variation in output of even new nozzles was found. Apparently the drill had not been accurately sharpened during the manufacturing process. A number of these new nozzles were found to vary from +25 to -8 percent of normal output when tested with water at 40 pounds' pressure. This variation agreed with the variation in the orifice when measured under the microscope.

Performance of Sprayer

The kind of liquid or formulation will affect the output from a nozzle. Light oils will flow through a nozzle more readily than water. Table 1 gives some of the variations to be expected with three formulations when using various flat-spray nozzles.

To test the distribution patterns from various nozzles, the entire spray (more than 96 percent) was collected in three photographic developing pans placed under the nozzle so that each pan collected one-third of the spray. When a Spraying Systems Company TeeJet nozzle No. 800067 was tested with water at a pressure of 50 pounds per square inch, and the spray was collected at 18 inches from the nozzle, each of the outer pans collected 21 percent and the center pan 58 percent of the spray. In a similar test a Spray Engineering Company nozzle No. 020 F[2/] collected 22 percent in each of the outer pans and 56 percent in the center pan. Several other nozzles delivered greater amounts on one side than the other. Since the nozzles give about twice as much output

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2/ Mention of commercial products does not constitute their endorsement by the Department of Agriculture.

in the center third, the nozzle height should be adjusted so that the outer third of the spray from each nozzle overlaps sufficiently to deliver a uniform spray across the boom. A series of small pans to collect the entire spray from the boom for a short time is an excellent means of checking the uniformity of spray patterns of a boom at a given height and spraying pressure. The boom must remain stationary for such tests.

Some colorimetric determinations[3/] were made from dye deposited on a 5- by 7-inch glass plate placed under each nozzle and at the center point between each two nozzles of the boom sprayer. The 15 plates were placed 14 inches below the boom. Unfortunately, the nozzles were not calibrated before the tests were made, as the need for this was not anticipated. A solution of 56 grams of DDT, 150 ml. of Velsicol AR-60, 10 ml. of Igepal, and 2 grams of Du Pont Sudan IV oil-soluble dye was emulsified with water to make 1 gallon of spray. The forward speed of the sprayer was 2.6 m.p.h. The pressure was 20 pounds per square inch. The nozzles used had holes drilled in both pieces. Table 2 shows the variation in the spray pattern across the boom. The odd numbers represent the plates directly under the nozzles. The first two tests were made with nozzles having an output of 0.047 gallon per minute, and the third test with nozzles delivering 0.107 gallon per minute.[4/]

Because of the variation in output of certain types of nozzles, it is recommended that, for accurate spraying, all new nozzles be calibrated before they are used. This can be done by forcing liquid through them at a known constant pressure and catching it in a suitable container while measuring against time.

Summary

A boom sprayer designed for spraying small field plots with uniform dosages of insecticide is described. Tests conducted with this sprayer showed that it is important (1) to calibrate each nozzle before using it on a boom, and (2) to make tests in advance with the nozzles in position, collecting the spray in pans across and under the boom so that any necessary adjustments in boom height and nozzle spacing can be made. Uniform distribution of the spray on the foliage depends on the density and height of the foliage and the constancy of the forward speed of the sprayer.

3/ Made by W. E. Bullard of the Division of Forest Insects, Forest Service, Beltsville, Md.

4/ The late T. N. Dobbins, of the former Bureau of Entomology and Plant Quarantine, assisted in making these tests.

Table 1.--Effect of formulation on output by various flat-spray nozzles on a Hanson sprayer.[1/]

Nozzle No.	Formulation[2/]	Cubic centimeters per minute			
		20 p.s.i.	30 p.s.i.	40 p.s.i.	50 p.s.i.
6501	Tap water	252	318	350	412
	DDT Em	250	310	346	412
	WP	228	306	346	398
6503	Tap water	694	832	960	---
	DDT Em	657	830	1035	---
	WP	676	882	1008	---
	WP[3/]	694	809	1002	1008
8001	Tap water	246	321	369	423
	DDT Em	255	330	377	436
	WP	235	318	368	422
8003	Tap water	684	868	988	---
	DDT Em	668	798	978	---
	WP	778	844	982	---

1/ Data contributed by J. T. Medler, Wisconsin Agricultural Experiment Station, and T. R. Chamberlin (retired) of the former Bureau of Entomology and Plant Quarantine.

2/ The emulsifiable concentrate contained 25 percent of DDT and was diluted at the rate of 2 quarts per 25 gallons of water. The wettable powder contained 50 percent of DDT and the spray contained 2 pounds per 25 gallons.

3/ These data obtained with an Oberdorfer pump.

Table 2.--DDT deposited on glass plates from an eight-nozzle boom sprayer. Pounds per acre.

Plate	Test 1	Test 2	Test 3
1	0.59	0.92	2.42
2	0.38	0.85	4.42
3	0.94	0.98	4.40
4	0.88	1.08	4.33
5	1.40	1.00	3.34
6	1.31	1.29	2.33
7	1.26	1.10	2.81
8	1.40	0.88	7.97
9	1.10	1.10	5.71
10	1.19	1.34	3.40
11	0.75	1.02	3.82
12	1.04	0.98	2.24
13	1.13	0.78	2.61
14	0.61	0.87	5.29
15	0.82	0.82	3.79

Figure 1.--A boom sprayer for applying insecticides to forage crops.